Robot for Coaching during Gait Training with Lokomat: Preliminary Experiment with a Multiple Sclerosis Patient

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Physical Rehabilitation

• “Around 15% of the world population has some disability” (WHO)¹
• Causes: neurological diseases such as stroke and spinal cord injuries (WHO¹).
• Physical Rehabilitation (PR) is a continuous process that seeks to improve the quality of life and self-reliance of patients².
• PR is focused on: physiological aspects and cognitive aspects².
• PR use several methods³.

¹“OMS, Atención médica y rehabilitación”, WHO, 2016
³O’Sullivan .S et al, [n.d], “Physical Rehabilitation”, 1505 pages
Physical Rehabilitation with Lokomat

• Lokomat is the gold standard device in the robot-assisted therapy.

• Enables effective and intensive gait training and ensures the optimal exploitation of neuroplasticity.⁴

  ✓ Increase the muscular tone⁵
  ✓ Balance improvement⁵
  ✓ Increase motor control and muscular strength⁶
  ✓ Superior to manual therapy⁷

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Limitations during Physical Rehabilitation

Lack of adherence of the patients to the programs.\textsuperscript{8,2}

\begin{itemize}
  \item Economical, social Factors.\textsuperscript{8}
  \item Anxiety, depression.\textsuperscript{8}
  \item Low level of physical activity or aerobic capacity, fatigue\textsuperscript{8}
\end{itemize}


Limitations during Physical Rehabilitation with Lokomat

- Multiple tasks performed by the therapists during a session.

Examples: Simultaneous measurements of gait patterns: ankle kinematics and spinal posture.

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Social Assitive Robotics

In this context, Socially Assitive Robotics (SAR) could be use as a potential tool to improve physical rehabilitation with Lokomat and to cooperate with therapists to control patient’s performance.

• Patien’s positive response in achieving different goals\textsuperscript{10}
• Improvement of the movement’s technical tasks during upper limb excersises\textsuperscript{11}
• Decrease the level of stress\textsuperscript{12}
• Usefull tool to engage the patients to excersise\textsuperscript{13}

\textsuperscript{11} Hee-Tae Jung et al. Upper limb excersises for post stroke patients through the direct engagement of an embodied agent. Proceedings of the 6th international conference- HRI. (2011).157
Human–Robot Interface Development

• Structure based on:
  • Physical parameters: Heart rate \(^{11}^{12}\)
    Cervical and thoracic posture.\(^{13}\)
  • Cognitive parameters: Motivational feedback, fatigue perception (Borg Scale)\(^{14}\)

13 Lunenburger, Clinical assessment performed during robotic rehabilitation by the gait training with Lokomat, (2005).
Human-Robot interface
## Robot Behavior

Table 1. Robot Behaviors during a therapy

<table>
<thead>
<tr>
<th>Behaviors</th>
<th>When?</th>
<th>Routine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical Posture Feedback</td>
<td>Bad Posture (10°-15° over 0°)</td>
<td>“your head is tilted this way, please correct it”</td>
</tr>
<tr>
<td>Thoracic posture Feedback</td>
<td>Bad Posture (10°-15° over 0°)</td>
<td>“Straighten your back”</td>
</tr>
<tr>
<td>Heart Rate alert</td>
<td>HR &gt;(206.9-(0.67*age))</td>
<td>“Therapist, your patient has a elevated heart rate”</td>
</tr>
<tr>
<td>Borg scale alert</td>
<td>BS&gt;15</td>
<td>“Are you tired”</td>
</tr>
<tr>
<td>Motivational Feedback</td>
<td>Good posture</td>
<td>“You are doing great”</td>
</tr>
<tr>
<td></td>
<td>Randomly</td>
<td>“You can do it”</td>
</tr>
</tbody>
</table>
Preliminary Study Design

- A male patient was randomly chosen (Height: 1.83 m, Weight: 60 Kg, Age: 62 years).

- Diagnosis: Multiple Sclerosis

- Lokomat features:
  - Speed: 1.5 m/s
  - 29.2% of body weight support
  - Therapy Time: 30 min
Results

Figure 1. Cervical posture registered by pitch, yaw and roll angles during 30 min of Lokomat session
Results

Figure 2. Thoracic posture registered by pitch, yaw and roll angles during 30 min of Lokomat session.
Results

According to the Borg scale, how tired are you?

“10”

Manual Borg scale register

Figure 3. Borg scale and heart rate during Lokomat session
Results

Figure 4. Main Events during 30 min of Lokomat
Conclusions

- The functionality and the usability of the system for this therapy was appropriate, showing reliable measurements.

- The robot gives different feedback corresponding to the variables and motivate the patient with randomly verbal phrases, allowing the interaction with the patient.

- This study shows initially the potential of SAR in physical rehabilitation with Lokomat for coaching in terms of support the patient and accompany the therapist’s task.

- Regarding the observations made in the preliminary pilot study, patients have a well-received behavior and a positive impact to SAR.
Social Assistive Robots in Physical Therapy with Lokomat

Center for Biomechatronics
## Current Work

Table 2. Initially results with 4 patients during two lokomat sessions

<table>
<thead>
<tr>
<th>Patient</th>
<th>Bad Cervical Posture Control session (Time)</th>
<th>Bad Thoracic Posture Control session (Time)</th>
<th>Heart Rate Mean Control session (bpm)</th>
<th>Bad Cervical Posture Robot session (Time)</th>
<th>Bad Thoracic Posture Robot session (Time)</th>
<th>Heart Rate Mean Robot session (bpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 1</td>
<td>17.2 min</td>
<td>5.07 min</td>
<td>92.01 bpm</td>
<td>9.04 min</td>
<td>2.4 min</td>
<td>92.2 bpm</td>
</tr>
<tr>
<td>Patient 2</td>
<td>7.63 min</td>
<td>6.84 min</td>
<td>80.4 bpm</td>
<td>6.04 min</td>
<td>1.5 min</td>
<td>95.2 bpm</td>
</tr>
<tr>
<td>Patient 3</td>
<td>18 min</td>
<td>9.3 min</td>
<td>82.3 bpm</td>
<td>3.5 min</td>
<td>1 min</td>
<td>85.04 bpm</td>
</tr>
<tr>
<td>Patient 4</td>
<td>9.9 min</td>
<td>1.2 min</td>
<td>96.4</td>
<td>2.32 min</td>
<td>0.9 min</td>
<td>98.4 bpm</td>
</tr>
</tbody>
</table>